DOCUMENT RESUME

ED 121 620 SE 020 761

AUTHOR Moreira, Marco Antonio
TITLE New Approaches to Teaching and Learning in Universities.
PUB DATE 75
NOTE 17p.; Paper presented at the International Conference on Physics Education (University of Edinburgh, July 29-August 6, 1975)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage
DESCRIPTORS *College Science; *Educational Innovation; Group Instruction; Higher Education; Individualized Instruction; *Instruction; *Physics; Science Education; Student Seminars; *Teaching Methods
IDENTIFIERS Keller Plan

ABSTRACT

This paper discusses new teaching approaches that are not heavily dependent on hardware, i.e., approaches that replace lectures with other activities such as small-group seminars and individualized instruction. Emphasis is placed on methods relevant to college physics education, such as the Keller Plan, modular instruction, audio-tutorial methods, small-group instruction, and team teaching. Suggestions are given for avoiding problems that arise in the implementation of new instructional systems. An annotated bibliography is included. (MH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED121620

NEW APPROACHES TO TEACHING AND LEARNING IN UNIVERSITIES*.

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Marco Antonio Moreira
Instituto de Fisica
Universidade Federal do Rio Grande do Sul
Porto Alegre, RS - Brasil

Abstract

The paper focuses primarily on new approaches that are not heavily dependent on hardware, i.e., approaches that can be achieved by replacing lectures with other activities such as small group seminars and individualized systems of instruction. Even in this area, it is not a complete survey but rather it emphasizes some widely adopted new approaches that seem to be relevant to physics education at the university level. The Personalized System of Instruction (Keller-Plan), The Audio-Tutorial Approach to Learning, Modular Instruction and Small Group Instruction approaches are described in the first part of the paper.

In the light of these approaches, independent study, mastery learning, criterion referenced evaluation, team teaching and other current ideas are discussed in the second part. In this part the administrative, logistic, instructional and learning problems found in the implementation of these new teaching formats are also discussed.

The third part is concerned with suggestions to avoid the problems and meet the challenges that arise in the implementation of new systems of instruction. The fourth part is an annotated bibliography on the subject covered in the paper.

*Trend Paper Nº 3, International Conference on Physics Education, University of Edinburgh, July 29th-August 6th, 1975.

SE020 761

NEW APPROACHES TO TEACHING AND LEARNING IN UNIVERSITIES.

Marco A. Moreira
Instituto de Fisica
Universidade Federal do Rio Grande do Sul
Porto Alegre, RS - Brasil

The purpose of this paper is to describe and discuss new approaches to teaching and learning in universities. However, considering the generality of the subject, some constraints will be used in order to achieve some objectivity. First, in spite of their importance, the paper will not deal with innovations that are heavily dependent on hardware as Computer Assisted Instruction (CAI) or Dial Access Systems, for example. The emphasis will be on innovations that do not heavily depend on hardware. Second, even in this area the paper will not be a complete survey, but rather will focus on some widely adopted new approaches that seem to be relevant to physics education at the university level.

The following approaches will de described and discussed : Small Group Instruction, The Personalized System of Instruction (Keller Plan), The Audio-Tutorial Approach to Learning and Modular Instruction. Independent Study, Mastery Learning, Criterion Referenced Evaluation, Team Teaching and other current ideas will be discussed in the light of these systems of instruction.

The first part of this paper will be a description of these innovations. The second and third parts will focus on the general tendencies as well as on problems and challenges that arise in the light of the findings of the first part. The last part will be an annotated bibliography. No claim about the novelty of the described approaches will be made except that they were being increasingly used during the last decade.

I - BRIEF DESCRIPTION OF SOME INNOVATIONS.

1) Small Group Instruction.

Small group techniques deemphasize lecturing on behalf of a greater degree of student participation during the classroom period. Different terminologies like "small group seminar", "small group tutorial" or "small group guided study" can be found in the literature. The basic idea, however, is that the class is divided into small groups and the students play an active role in the

instructional situation .Group size ranges,roughly,from 4 to 8 students.

Falk and Wall (1970) described one of these tecniques where all members of each group were prepared to lecture on a given topic.By having each group present its topic to the other groups some involvement of each student with almost all the material was maintained throughout the semester.Meetings between the teacher and individual groups were used to keep general control over the course,to make sure that the key points weren't missed,to help students in more difficult sections,etc.

In another report,Moreira and Costa (1971) described the following technique : At the beginning of each class,after a brief introduction,the students received a handout containing questions and problems to be solved in small groups.A report of each group's work was due at the end of the class. During the class the teacher circulated among the groups guiding their work and providing assistance when necessary.

Munsee (1972) reported a similar technique : The students were randomly grouped in small groups and a group project was assigned. The students had a lot of freedom to decide on a pace at which to cover the material of the course as well on the project. During each class period the teacher circulated among the groups helping them when needed.

Black,Griffith and Powel (1974) described a small group teaching method (skill sessions) designed to help students in acquiring some of the specific skills which are needed in the practice of physics. For example,a skill session may be concerned with estimating orders of magnitude.In a skill session a group of about 16 students meets a teacher for one hour. The teacher spends a few minutes explaining why the particular skill is useful to a physicist. The students are then divided into four working groups and each group is asked to choose one out of a set of four problems,to work as a group and to be ready to report their findings in about 30 minutes. During the next half hour the groups discuss their ideas. In the last few minutes the teacher might briefly sum up the discussions. This type of session is being tried in about six departments of physics in British universities at the moment.

In general,the small group approaches are designed to replace lectures (but they don't necessary exclude them or other large group activity),however,they can also be used in a laboratory session. The evaluation of the students is usually based on the group activity as well as on individual homework assignements,quizzes and examinations. Course reports usually claim that the students enjoy the small group approaches,they

learn as much as in the lecture method, they participate actively and feel a deeper involvement with the subject matter. It is also claimed that personal interaction is enhanced and a more informal student-teacher relationship is developed.

2) The Personalized System of Instruction (PSI).

Also known as the Keller Plan, PSI is the most widespread new approach to teaching and learning in universities. It is an individualized approach based on the learning- reinforcement theory, with the following basic features(Keller, 1968):

1) The go-at-your-own pace feature, which permits a student to move trough the course at a speed commensurate with his hability and other demands upon his time.

2) The unit-perfection requirement for advance, which lets the student go ahead to new material only after demonstrating mastery of that which preceded.

3) The use of lectures and demonstrations as vehicles of motivation, rather than sources of critical information.

4) The related stress upon the written word in teacher-student communication.

5) The use of proctors, which permits repeated testing, immediate scoring, almost unavoidable tutoring, and a marked enhancement of the personal-social aspect of the educational process.

A great number of courses based on these five features have been designed during the last ten years. Examples of physics courses can be found in reports by Green(1971), Anderson and Artman(1972), Austin and Gilbert(1973) and Moreira (1975). In general, course mechanics are as follows:

Course material is divided into units, and for each unit a study guide is prepared. It contains objectives, reading assignements, study questions and problems, references and introductory or explanatory materials if necessary. The student proceeds through the material at the rate, time and place he chooses. A proctor (a student selected for his mastery of course content) is available during class periods for individual assistance. The teacher is also available, but to a lesser extent because the ratio students/teacher is usually high as compared to the ratio students/proctor which is about 10.

When the student feels he has mastered the unit-objectives, he requests and takes a test on the unit. The test is immediately evaluated by a proctor in the presence of the student.

Sometimes the evaluation is made by the teacher, but he usually acts indirectly providing answer sheets to the proctors and scheduling meetings to discuss the unit-tests with them. On the unit-test the student is required to show that he has mastered the objectives of the unit, i.e., he is required to answer correctly all items(some teachers require only 80 or 90%) . If the student passes the test he receives the study guide of the next unit and is encouraged to proceed.If he does not successfully complete the test, he is encouraged to restudy the unit and take another test on the same unit. No matter how many times a student is required to retake a unit, there is no penalty ,his grade is not affected.

Usually, all the students who complete all the units receive an A grade (a large number of A's is typical of PSI courses) and other grades are given as a function of the number of completed units. Sometimes final exams are also used, but they don't have a dominant weight in the final grade.

Some lectures are given during the course for students who have completed a certain number of units and are qualified to understand the material to be covered. However, attendance is not required and the lecture material is not included on the unit-tests. Laboratory work can be either part of a unit or an independent unit.

Answering end-of-course questionnaires, a great majority of the students say they have enjoyed the course, they would like to take another PSI course and they would recommend PSI courses to their friends. They also say they have worked harder and they felt they "have learned more". Comparisons between PSI and lecture methods in terms of achievement in final exams and retention tests suggest that PSI is at least as effective as conventional approaches. The personal interaction among student, proctors and teachers is usually emphasized in PSI course reports.

3) The Audio-Tutorial Approach to Learning (AT).

Basically, in the AT system a wide variety of learning experiences is provided in an integrated form and the student's activity in these learning experiences is guided by audio-tapes. Originally the system includes three major types of study sessions (Postlethwait, Novak and Murray, 1972):

a) Independent Study Session (ISS): Weekly AT programs are placed in a learning center equiped with carrels for individual study. Each student could pace his study proceeding independently through the material to achieve the stated objectives for the week.

b) General Assembly Session (GAS): Lectures, special films, major exams or other large group activities scheduled on

a weekly basis.

c) Integrated Quiz Session (IQS): A small group session, scheduled to meet weekly for one half-hour, that involves eight students and an instructor. For this session each student is expected to prepare a little lecture about the material studied in the ISS.

Presently, the AT approach is closely identified with a learning center where the student can work individually , stopping at any point in the program to use additional resources such as supplemental texts and discussions with the instructor on duty or with peers. The basic equipment of a carrel is a tape recorder (which may be an inexpensive cassette type) with head_ phones, a slide projector and materials (laboratory equipment , for example) appropriate for the subject being studied. If possible, film-loop projectors should be also available. Even closed circuit TV and computer terminals may be used in a sophis ticated AT learning center.

In spite of being developed independently, AT and PSI can be combined. For example, in the Physics Department of Cornell University (Naegele, 1974) an AT approach entirely self-paced, using a mastery based PSI type of evaluation is being used to run a large introductory physics course. Students study the units in a large learning center where the materials of different units are available simultaneously. Videotaped lectures are available upon request from the students. Unit-tests are taken in a testing center.

Evaluations of the AT approach also show a high degree of student satisfaction, an enhancement of personal interaction and an effectiveness, in terms of achievement, at least equal to the conventional approaches. The AT system can also be used (as well as PSI) in conjunction with minicourses or modular units.

4) Modular Instruction (Modules).

A module may be defined simply as "a self-contained and independent unit of instruction with a primary focus on a few well-defined objectives" (Creager and Murray, 1971). "Learning packages", "instructional packages", "audio-tutorial packages" , "minicourses", "conceptopaks" are some of other names given to modules.

In general, the components of a module are (Creager and Murray, 1971) :

Statement of Purpose(Rationale): description of the purpose of the package.

Desirable Prerequisite Skills : if partidular skills are needed before the beginning of a module, they should be stated explicitly.

Instructional Objectives: they describe what the learner

should be able to do after completing the module.
Diagnostic Pre-test: to determine whether or not the student is prepared to undertake the module. Outstanding performance may indicate that the student need not take the module.
The Modular Program : learning activities and instructions so that the learner can independently complete the module. These activities may include writing, reading, listening, viewing, etc. Different learning activities to achieve the same objectives provide the learner with an opportunity to follow his own particular learning style.
Evaluation Post-Test : to provide an index of the learner's accomplishments.

Modules may also include lists of equipment and supplies, self-evaluation tests, optional activities, teacher's guide, etc. Modular instruction is characterized by its flexibility. Modules can be used in a PSI or AT course or even in a more conventional course. They can be arranged in a variety of sequences to meet the individual needs of each student. Some modules can be studied at home. They also can be shared among institutions. Undoubtedly, modules offer a wide range of instructional possibilities.

II- a) EMERGING PATTERNS

Individualized Instruction - Independent Study.

Individualization of instruction, in a broad sense, is the general tendency. Even the small group approach tends to individualize instruction if compared with large group instruction and can be interpreted as a link between these two instructional modes. This tendency leads to a student centered process characterized by a certain degree of independent study. The learning conditions are organized to allow students to proceed at their own pace and to choose learning activities compatible with their learning styles. Independent study which for long time was a privilege of a few outstanding students now is extended to a broad spectrum of students.

Objectives - Mastery Learning - Criterion Referenced Evaluation.

Clearly stated objectives specifying what the student is expected to do, under what conditions and to what level of performance, are a necessary component of study guides and modules. Usually these objectives are associated with the basic assumption that, provided necessary learning conditions, they can be mastered by all students. Mastery learning (Block, 1971) is naturally associated with individualized instruction. In a PSI course, for example, the student can retake a unit-test as many times as necessary to master the content of the unit at the level specified by the unit objectives. Student evaluation in mastery learning practices is criterion referenced (the objectives establish the criteria) whereas traditional instruction is norm

referenced. In the first case the student is essentially in competition with himself to achieve the objectives, whereas in the second case he is in competition with the others to obtain a position on a normal curve.

Personal Interaction, Student Cooperation, Different Type of Student-Staff Relation.

An enhancement of personal interaction is usually reported in individualized or small group courses. Student cooperation and peer-teaching are a natural consequence of small group arrangements, of the use of proctors and of the simple fact that students are not in competition against each other, since criterion referenced evaluation is used. As the new approaches move toward individualized instruction, the pattern in student-staff relations move from teacher-dominated activities to student-centered activities with various forms of student-staff cooperation (Novak, 1972). As a consequence, the student-staff relation is quite informal and personal interaction is enhanced at this level too.

The Role of the Teacher - Team Teaching.

As lecturing is strongly deemphasized, the role of the teacher necessarily changes. He now defines objectives, designs and prepares instructional materials, provides individual assistance, monitors student's progress, gives occasional lectures, encourages the students for good performance, evaluates the system, etc. This is enhanced by teacher cooperation. Team teaching, a quite common approach in elementary and secondary schools, is now being used at college level to handle large individualized courses. Basically, the idea is that two or more teachers share the instructional and administrative activities of a course in a way that teachers as a team plan, conduct and evaluate the course for all students.

The general tendencies identified above can be schematized in the diagram presented in Fig.1.

b) SOME PROBLEMS AND CHALLENGES.

The problems found in the implementation of these new approaches can be tentatively divided in two large categories: 1) Administrative and Logistic Problems; 2) Instructional and Learning Problems. Some of the problems that can be listed in the first category are:

- Cost. In a PSI course, for example, proctor's payment and a large amount of printed materials may significantly increase course's budget. In an AT or Modular approach a substantial amount of money must be invested to implement and maintain the system.

- Facilities. Adequate facilities for individualized and small group activities must be provided. However, an inexpen

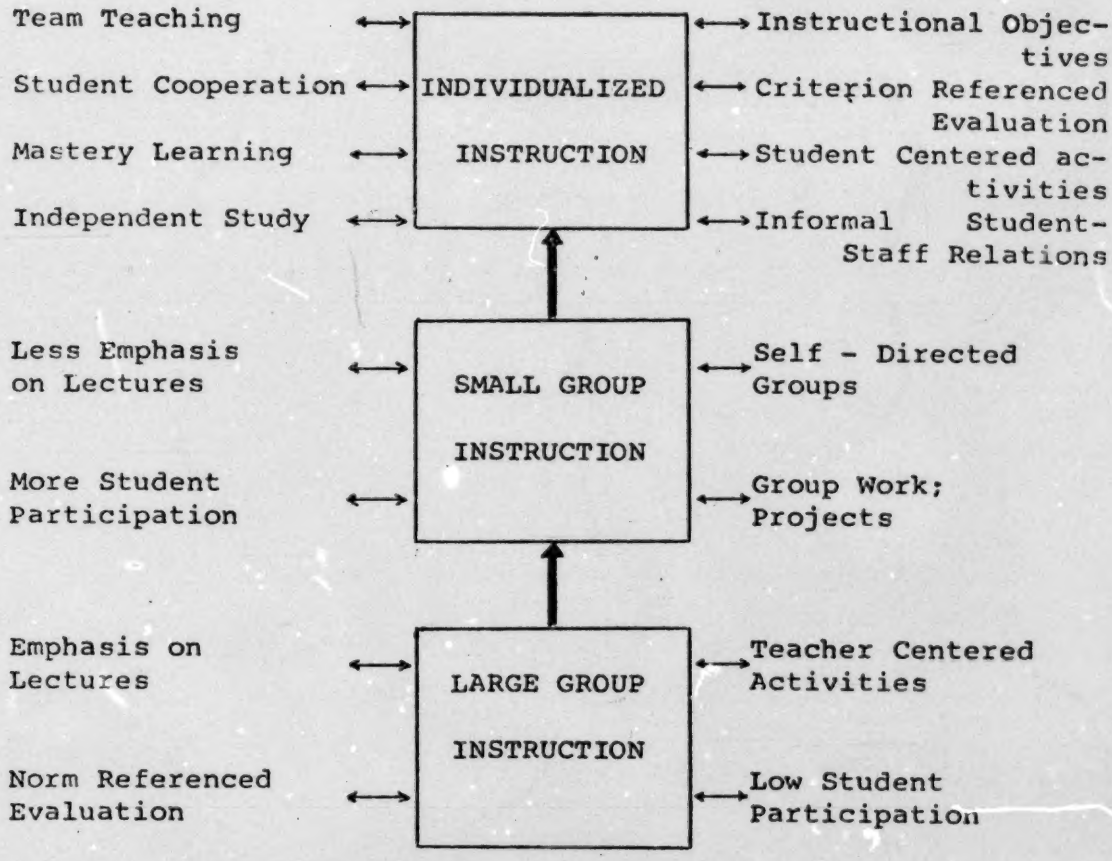

Fig. 1 - Evolving pattern in instructional approaches at university level.

sive adaptation of the existing facilities may solve the problem.

- Lack of Teachers and/or Assistants (proctors). Usually these are problems related to the cost, but they may also reflect a lack of prepared manpower. This problem makes almost impossible the implementation of an individualized system of instruction.

- Course Management. Records must be kept; printed materials must be prepared, revised and organized; laboratory equipment must be ready to be used at any time; proctor's work must be supervised; schedules must be organized, etc.

- Resistance to Innovation. This may come from various sources:the administration that is not receptive to changes in established teaching and grading policies; faculty members that foresee innovations as some kind of future pressure to change their teaching methods; students with outstanding performance in traditional courses that under new formats see everyone as being able to obtain an A, etc.

In the category of instructional and learning problems the following may be included(not necessarily ranked) :

- Staff. First of all, the success of the new approaches is heavily dependent on the quality of the instructional materials prepared by teachers(this preparation is extremely time consuming and requires expertise in educational technology). The degree of involvement of the teacher is also a fundamental variable. Another danger is to increase the ratio students/teacher in such a way that the course is ultimately under proctor's responsibility.As far as proctor's are concerned, particularly when a large number is necessary, problems arise to recrute and train them. The success of a PSI course,for example,relies to a large extent on proctor's performance which depends not only on his degree of mastery of the content but also on the ability to establish personal relations.

- Student Dependency. The student may develop an attitude of not being able to study without receiving detailed instructions to follow. However,if the study guides are carefully prepared and the instructions change as the student progress in the course, a high degree of independence in learning may be generated instead of dependency.

- Automation may be an undesirable effect when individualized approaches are used with a large number of students. The use of technological devices in education increases the possibility of automation. Modules, AT programs, computer assisted instruction,etc., tend to mechanize instruction when used with many students. But,how to avoid automation if hundreds and hundreds of individuals must be effectively educated? It seems that some sort of compromise between the use of technology and human interaction in the educational process must be established in order to achieve efficiency.

Many control rules must be established when the number of students is too large (eg. 300 students) and this contributes to mechanize the course making it less pleasant.

-Procrastination and high number of withdrawals. As the students may proceed at their own pace,some of them tend to procastinate and,eventually,withdraw. Establishing deadlines for finishing units is one type of solution used. However, it is basically against the idea of self-pacing. Furthermore,these

problems may be more related to course programming than with student's ability to self-pace.Too long or too difficult study units,for example,may be a relevant factor influencing procrastination.

- Cribbing and memorized answers (Moreira,1975) to test items may occur.Computer generated tests may be a solution to avoid cribbing.However,this type of student attitude may also be related to programming,i.e.,it may be fostered by poorly designed instructional materials.

-Lack of content integration may happen as a consequence of dividing the content into small units or modules. This is particularly true when the units are prepared without regard to more general concepts and laws.Review units and a better conceptual organization of course content may be a solution for such a problem.

-Rote Learning, i.e.,learning new information in an arbitrary form or just memorizing them without meaningful associations with previous knowledge may also occur. It may be promoted if the individualized material are designed without reference to cognitive structure and if test items are so simple(to be taken and evaluated in a short period of time) that just rote learning is required.

Concerning the small group approaches some problems may be also identified. This type of activity if not teacher guided,may just promote friendly relations among students in a group. Some group members may have a limited degree of participation either on a voluntary or unvoluntary basis.If the small group sessions are to be articulated with other types of sessions, this articulation may be a problem.

This is not a complete list of problems that may arise in the implementation of new approaches;however,they certainly constitute a challenging list for innovators.To some extent they are being attacked and solved by those that are already using the described approaches.

III - SOME SUGGESTIONS.

Generally speaking, many problems are likely to be avoided if the innovations are officially supported;if they are implemented by teachers with solid preparation in the subject matter and skilled in designing instructional materials; if they focus on how students learn and if effective methods of assessing the new instructional strategies are designed.

By official support it is meant that the university administration should approve and provide the necessary material and human resources during the experimental phase of an educa

tional innovation. Subsequently, if the innovation prove to improve effectively the instructional and learning processes, additional resources for the implementation and operation of the new system on larger scale should be provided by the adminstration.

Assuming that teachers are well prepared in the subject matter, they should be also prepared in terms of new instructional technologies. They should be trained to prepare instructional materials. An obvious consequence of this statement is that the opportunity for such a training should be provided by the educational agencies.

Focusing on how students learn means that innovations should be based on a theoretical learning framework. Ultimately the aim of any innovation is to promote learning. Consequently, it makes no sense to design a new approach without using a learning theory as a frame of reference.

Effective mechanisms of evaluation will assess the effectiveness of the new system and provide feedback to correct the system and solve problems.

Concerning cost, it is suggested that the agency supporting an educational system must analyse the cost of an innovation in terms of its results. For example, a new approach apparently more expensive may reduce failures and turn out to be more economical than an inexpensive (apparently) system that fails 50% of the students.

More specific suggestions to avoid problems and meet the challenges of implementing a new approach are as follows:

-It should be tried first with a small group (e.g. 20 students) and the results carefully assessed. If the objective is to run a large course (e.g. 500 students) under the new format, then the number of students should be increased progressively up to the point that the teacher is able to make the necessary extrapolations. At that point he should be able to estimate how many instructors, proctors and aids (secretary, laboratorists, technicians, etc) will be necessary to run the large course. He should also be able to specify the type of facilities, to estimate the amount of printed material, the necessary equipment, etc. Then he should present the results of his first trials and his estimates to the administration to obtain the necessary support. If the support is not provided, it is better not to use the new method. To run a large course under a new format relying only on the work and enthusiasm of a few teachers and proctors increases the probability of facing problems, distortion of the system and eventual failure in spite of the enormous effort made. For example, in a PSI course the ratio students/staff member shouldn't be "stretched" to make "economy". Usually ratios of 50 students/teacher and

10 students/proctor give good results and should be recommended.

- Direct teacher participation is fundamental. He must interact with the students or groups in the classroom (study hall), laboratory or learning center, at least during the periods of time officially assigned to the course. He should also evaluate some unit-tests, but he should not act permanently as a proctor because he will loose his mobility. This direct participation has a positive effect on student's attitudes and provides a direct and constant measure of the development of the course.

- Finally, a suggestion about the instructional materials: if they are designed to be used individually they should really attempt to accomodate for the range of individual differences. Just dividing the text book into units (usually corresponding to chapters) and writing uniform study guides usually results in a linear sequence implicitly directed to an average student which is also the target of a conventional lecture approach. In such a case the affective response of the students may be favorable (a positive attitude toward the course) but the cognitive achievement is likely to be no better than that of a conventional format.

Procrastination, high number of withdrawals and cribbing may be a result of such type of linearity and uniformity in the program. Students differ in their cognitive structures, skills and learning styles. A rigid sequence of units with the same learning activities in each step, will be adequate only to some students and will generate different reactions from the others. Rote learning and lack of content integration may also be consequences of a bad program.

The probability of having instructional and learning problems will be decreased if the course program is flexible, providing different pathways, for example, if different learning activities are suggested in each unit or module, if the prerequisites are clearly stated and remedial situations are provided when necessary, etc. Individualized instruction has a great potentiality to promote meaningful learning (as opposed to rote learning) and affective growth. If this the potentiality is truly explored in designing instructional materials, teachers will not be compelled to be satisfied with results like "the students really enjoyed the course even though they learned no more than they would have learned in a conventional approach".

IV - AN ANNOTATED BIBLIOGRAPHY

Anderson, O.T. and Artman, R.A. Self-Paced, Independent Study, Introductory Physics Sequence - Description and Evaluation, American Journal of Physics, vol. 40, no. 12, December 1972, p.1737-1742. Description of an individualized program for a three-course sequence in physics.

Austin,S.M. and Gilbert,K.E. Student Performance in a Keller-Plan Course in Introductory Electricity and Magnetism, American Journal of Physics, vol.41,no.1,January 1973, p.12-18.Comparison between PSI and a lecture-recitation format through a common final examination and a retest taken two months after the course.(Included in section II of 41 Germinal Papers, edited by J.G.Sherman.)

Black,P.J.,Griffith,J.A.R. and Powell,W.B. Skill Sessions, Physics Education, vol.9,no.1,January 1974,p.18-22. Description of a small group teaching method designed to help students in acquiring skills which are needed in the practice of physics.

Block,J.H. (Ed.) Mastery Learning: Theory and Practice. New York, N.Y. :Holt,Rinehart, and Winston,Inc.,1971,151p. A collection of articles focusing on both the theory behind mastery learning and the operating procedures to implement a mastery strategy in a course, subject or even an entire curriculum.

Creager,J.G. and Murray, D.L. (Eds.) The Use of Modules in College Biology Teaching. Washington,D.C.: Commission on Undergraduate Education in the Biological Sciences, 1972,173p. A collection of papers on various aspects of modular instruction. In spite of focusing on biology,the book is useful for everyone who is interested in implementing a modular approach in his own course.

Falk,D.S. and Wall,N.S. An Experiment in Undergraduate and Graduate Teaching and an Evaluation, American Journal of Physics,vol.38,no.12,December 1970, p. 1485-1487. Description of a small group approach in a graduate course in solid state physics and in an advanced undergraduate course in nuclear physics.

Green,B.A. Jr. Physics Teaching by the Keller Plan at MIT, American Journal of Physics, vol.39,no.7, July 1971, p.764-775. This is the classical paper describing the use of PSI in a physics course.(Also included in section II of Sherman's book.)

Guides to Innovation in Physics Teaching. Stony Brook, N.Y.: American Association of Physics Teachers Publications, 1974.A set of three guides containing a total of 1400 entries giving brief descriptions of college-teaching innovations,name and address of innovators. The first volume lists self-paced courses(PSI,AT and Minicourses) the second focuses on courses for nonscientists and the third stresses innovations in areas like course content and laboratory in courses for physics majors.

Keller,F.S. "Good-bye Teacher...", Journal of Applied Behavior Analysis, vol.1,no.1, p.78-89.This is the major reference paper in PSI. It describes PSI, applied to a psychology course, as it was conceived by its creators. (Included in section I of Sherman's book.)

Moreira,M.A. The Use of the Personalized System of Instruction in an Introductory College Course in Physics during Four Consecutive Semesters, invited working paper for the International Conference on Physics Education, University of Edinburgh,Scotland,July 29- August 6,1975. Description,data and critical analysis of the progressive implementation of a PSI course from 48 students in the first trial to some 300 three semesters later.

Moreira,M.A. and Costa,M.E.V. O Professor como Organizador das Condiçoes Externas da Aprendizagem (The Teacher as an Organizer of the External Conditions of Learning), Revista Brasileira de Fisica,vol. 1,no. 3,1971, p. 453-468. Description of a small group approach used in a large scale in an introductory college physics course.

Munsee,J.H. An Evaluation of a Nonlecture Technique in the Teaching of Physics, American Journal of Physics, vol.40,no.8,August 1972,p. 1119-1125.Description of a small group technique used in introductory college physics.

Naegele,C.J. An Evaluation of Student Attitudes,Achievement , and Learning Efficiency in Various Modes of an Individualized,Self-Paced Learning Program in Introductory College Physics.Unpublished Ph.D. Thesis, Cornell University,1974, 390 p. This thesis is concerned with the production,organization and evaluation of an individualized audio-tutorial program of instruction in introductory college physics.

Novak,J.D. Facilities for Secondary School Science Teaching: Evolving Patterns in Facilities and Programs.Washington, D.C.: National Science Teachers Association,1972, 173 p. This is a report of a study carried out in some 140 secondary schools in USA. However, the evolving patterns identified by the author may also be applied to universities.

Postlethwait,S.N., Novak,J.D. and Murray,H.T.Jr. The Audio-Tutorial Approach to Learning, Minneapolis,Minn.: Burgess Publishing Co.,1972,184 p. A complete description of the AT system. Although the description

focuses on botany courses, the general ideas apply to any course. The book includes one chapter (VI) on minicourses (modules).

PSI Newsletter, Washington, D.C.: Center for Personalized Instruction, Georgetown University. A newsletter designed to provide information about PSI courses and events like workshops and conferences. It also includes short articles on PSI.

Sherman, T.G. (Ed.) Personalized System of Instruction: 41 Germinal Papers . Reading, Mass.: W.A. Benjamin, Inc., 1974, 225 p. A collection of papers designed to serve as a guide to those who wish to use PSI. The first section is concerned with data, method and evaluation mainly in psychology courses. Section II includes papers on the use of PSI in physics and other disciplines. The third section focuses on problems found to implement PSI courses and two remaining sections are concerned with related developments , history and theory of PSI.

The Yellow Pages of Undergraduate Innovations. Ithaca, N.Y.: The Cornell Center for Improvement in Undergraduate Education and Change Magazine, 1974, 243 p. A general directory of innovations containing name, address and phone number of innovators.